Optical spectroscopy of CdSe/ZnSe quantum dots with single Fe^{2+} ions

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Reaching limits of miniaturization related to atomic structure of matter poses an important challenge of our times. A question arises whether further development of technologies such as nanometer scale electronics and material science is going to be limited by a finite size and discrete structure of electronic states of single atoms. Or, conversely, if we are able to take advantage of properties of individual ions or defects, as it is proposed in solotronics [1], a rapidly developing area of research and technology of optoelectronics exploiting solitary dopants.

Our approach to solotronics is based on introducing individual dopants of transition metal (TM) ions such as Mn, Co, and Fe to quantum dots (QDs). Since single TM ion modifies properties of a QD [2], we can study spin configuration of TM ion using optical transitions of a QD.

We find that comparing to bulk, nanostructures such a QDs strongly modify magnetic and optical properties of TM ions [3]. Most striking example is the case of Fe^{2+} ion. In bulk zinc blende crystals Fe^{2+} ion exhibits a non-degenerate ground state, which leads to rather weak response to the magnetic field. In contrast, high strain of the QD changes the character of the energy spectrum of the Fe^{2+} ion leading to formation of doubly degenerate state with spin $S_z = \pm 2$ [4,5].

[1] P. M. Koenraad, M. E. Flatte, Nat. Mater. 10, 91 (2011).
[2] L. Besombes et al., Phys. Rev. Lett. 93 207403 (2004).
[3] J. Kobak et al., Nat. Commun. 5, 3191 (2014).
[4] T. Smoleński, et al., Nat. Commun. 7, 10484 (2016).
[5] T. Smoleński et al., Phys. Rev. B 96, 155411 (2017).